RESEARCH HIGHLIGHTS

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HOUSE DUST: A USEFUL TOOL TO ASSESS MICROBIAL CONTAMINATION IN HOMES

Introduction

In recent years, there has been increasing concern about indoor air quality in houses. The family home can sometimes become a source of microbial contamination, where molds and bacteria proliferate. Inadequate ventilation and high moisture levels resulting from water damage episodes or excess humidity often cause the proliferation of fungi (molds) and bacteria on visible surfaces or hidden inside structures. In such a context, a good diagnosis of the degree of microbial contamination in homes becomes more important. Unfortunately, assessment tools are few and insufficient. Air sampling, still frequently used, is an incomplete tool, which is not reproducible and can lead to false negative results. On the other hand, surface samples are useful to document the nature of visible fungal contamination but insufficient to obtain a global diagnosis (ACGIH, 1999).

Field experience has led some researchers to promote the use of house dust microbial analysis, as it represents the "memory of a building" providing valuable information on its microbial history. This project was conducted to obtain dust analysis data from homes with no history of moisture damage to compare with water damaged homes. Thanks to an External Research Program grant from CMHC, it was possible to inspect more than fifty healthy homes, and analyse their dust microbial contents. The data from non-moisture damaged homes was added to the researcher's own existing database of hundreds of unhealthy homes to allow comparison of the two data sets, and confirm the validity of the method.

Methods

Healthy home selection

Homes in the Montreal area were recruited by advertising in two newspapers, direct faxing, door-to-door distribution of a brochure, and word of mouth. A selection was made using a telephone questionnaire to eliminate homes that did not meet the microbial health criteria established for this project, including these main conditions: no major water damage during or since the 1998 ice storm, no health problems having appeared or worsened since moving in, at least two years of occupancy, no carpets in the basement, no poorly maintained forced air heating systems with porous insulation in the ductwork, or with humidifiers.

Inspection protocol

The building inspections were carried out by inspectors from Groupe Natur'Air-Kiwatin of Montreal. Each site visits lasted a minimum of one hour and a half, and consisted of a comprehensive inspection of both the outside and inside of each house, checking the structures with a moisture detector, conducting a complementary survey with the occupants, taking photographs, and sampling dust.

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Dust sampling
The inspectors used a portable Hoover Portapak vacuum cleaner with disposable paper bags to collect a composite sample of dry settled dust from the occupied rooms. Samples were not taken from the floor to avoid tracked-in dirt and spores brought in from outside on shoe soles, or accumulated dirt and spores in carpets. Dust was sampled higher, for example on bookshelves, kitchen shelves, door frames, etc., where it had deposited from the air at the occupants' breathing level. Depending on the degree of dust accumulation in the house, the total sampling area in the dwelling could be anywhere between 1 and 2 square meters (precisely measured). Vacuuming lasted 5 minutes on each surface. After sampling, the vacuum cleaner bag was removed, sealed with adhesive tape and identified with a number. It was then placed in a tightly sealed plastic bag and brought to the Microvital laboratory where it was kept at 4 degrees C until put in culture, with a maximum delay of 6 days from the time of sampling.

Analysis of dust samples
Samples from healthy houses were analysed at random along with other samples being provided to the lab. The healthy house sample numbers had no distinctive indicators to differentiate them from other samples. Therefore, the healthy house samples were impossible to recognize among the others being analysed. Suitably diluted in sterile water, dust samples were plated on MEA Rose bengal culture dishes for mold and on PYA for bacteria. Duplicates of total bacteria were counted under the dissecting microscope after 48 hours of incubation at room temperature. Duplicates of fungi were counted under the dissecting microscope after 7 to 14 days of incubation at room temperature, depending on their speed of sporulation. The molds were identified to the genus level, and to the species level in some cases.

Results

Fungal counts, extent of water damage and season
The dust from healthy homes, with a mean value of 74 366 colony forming units per gram (cfus/g), contained up to seven times less mold than that of their water damaged counterparts, with a mean value of 482 004 cfus/g. The difference was highly significant (Wilcoxon/Kruskal-Wallis $p<0.0001$). These results statistically confirm the Ontario Wallaceburg study (Miller and al, 1999) where fungal counts from dust sampled in 20 out of 400 homes, with the most extensive water damage episodes, were 10 times higher than fungal counts from the 20 homes without excessive water activity.

Fungal contents of dust from all homes is not significantly influenced by season (two way ANOVA $p>0.05$). Furthermore, there is no interaction between season and the extent of water damage (two way ANOVA $p>0.05$). This confirms that water damage alone makes a significant difference in fungal counts from house dust.

Ratio of non phylloplane to phylloplane fungi in dust related to extent of water damage
Cladosporium and *Alternaria* are the phylloplane fungi (mostly found in air and growing on trees or plants), and *Penicillium* and *Aspergillus* the non phylloplane fungi (mostly from soil) found most frequently in the dust of the inspected homes, whatever their contamination levels. Phylloplane fungi predominate in healthy homes and non-phylloplane fungi predominate in unhealthy homes. Thus, the ratio of non phylloplane to phylloplane fungi for unhealthy homes (1.51) more than doubles that for their healthy counterparts (0.70). The difference is highly significant (ANOVA p 0.00040 for phylloplanes and 0.012 for non phylloplanes).

Bacterial dust counts and extent of water damage
Mean bacterial counts are more than twice as high in unhealthy homes, with 1.45 million cfus/g of dust, compared to healthy homes, with 678 088 cfus/g. However, the standard deviation is too high to confer statistical significance to these data (Wilcoxon/Kruskal-Wallis $p>0.05$).

Many factors can explain these findings, for example the presence of pets, cold water humidifiers or sump pumps with improper maintenance, the season of inspection, etc. Due to insufficient sample size, there were not enough homes with each of these separate characteristics to allow statistical analysis of the bacterial counts in dust. The inspection findings indicate however, that all these factors do have an influence on counts of bacteria in house dust.

Conclusions

This study confirms the reliability of house dust sampling as a complementary diagnosis tool for the assessment of microbial contamination indoors. The fungal contents of house dust can be a good indicator of the extent of water damage and represent the "microbiological memory" of houses. Dust from unhealthy homes can contain up to seven times more mold than that of their healthy counterparts and the fungal distribution often shows a majority of non phylloplane species in these water damaged homes.

However, mold testing is generally not required to determine the presence of mold in houses. The odours and visible signs of moisture and mold are usually all that is required to assess a mold problem. The mold test

results do not influence the remedial actions to be taken in houses. Visual inspections and proper diagnostic of the moisture sources that led to the presence of mold are more useful to homeowners to help them resolve a problem.

No sampling method is perfect. Air samples, for instance, measure the microbial contents of air only at the precise time of sampling, with frequent risks of false negative results. The microbial contents of dust is a better indicator of the house's microbiological memory, however, in some cases it might not correspond with the inspection data in the field. Mold testing may be required to document a case i.e. for litigation, but it is rarely warranted simply to identify the presence of mold, determine the remediation measures, or to resolve the moisture conditions to avoid mold growth. Sound judgment is to be used on a case-by-case basis to choose the most appropriate diagnostic method(s) and avoid unnecessary sampling.

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Housing Research at CMHC

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